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ABSTRACT

The Learning in Science Project investigated the proportion of students at different ages who considered a horse, person, dolphin, worm, and spider to be animals. Although scientists would agree that they are indeed animals, findings indicate that many students of varying ages did not consider them to be animals; similar findings were reported for students' views of "plant" and "living." In addition, it is suggested that meanings many children give to these words indicate that their hierarchical categorization may not be the same as that of scientists. One possible explanation may be that teachers have assumed students have scientific meanings for these commonly used words and have not focused their teaching on them. Therefore, this booklet was prepared to serve as background information for suggested teaching activities by providing discussions of both scientists' and childrens' views/conceptions of "living," "animal," and "plant." Included in these discussions are selected student comments obtained during the second (in-depth) phase of the project. (Highlights of the in-depth phase, focusing on interview techniques, are provided in an appendix). (JN)

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ANIMAL, PLANT, LIVING:

Notes for teachers

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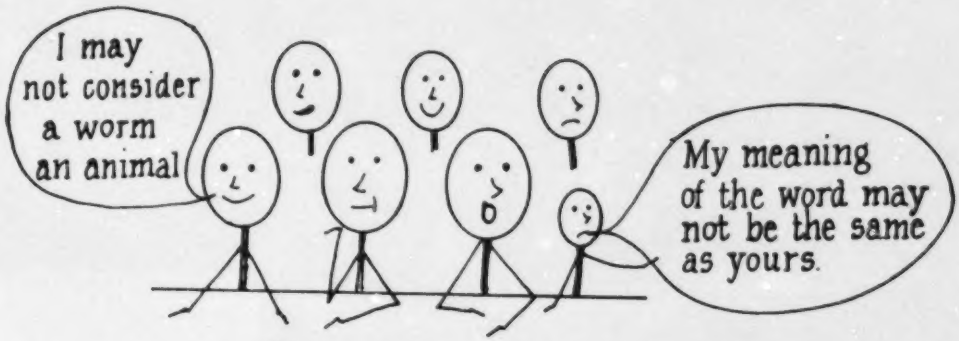

Your class

Non-living

This way to non-living things

This way to living things

Living

Plants and....

animals

ANIMAL, PLANT AND LIVING: NOTES FOR TEACHERS

Beverley Bell

November 1981

The Problem

Children do have meanings for the three basic words we use in biology lessons - animal, plant, living. But these meanings are not necessarily the same as those used by a scientist.

The Learning in Science Project investigated the proportion of pupils at different ages who considered a horse, person, dolphin, worm and spider to be an animal. A scientist would consider them all to be animals, but the survey results (see figure 1) indicate that many students of varying ages did not consider them to be animals.

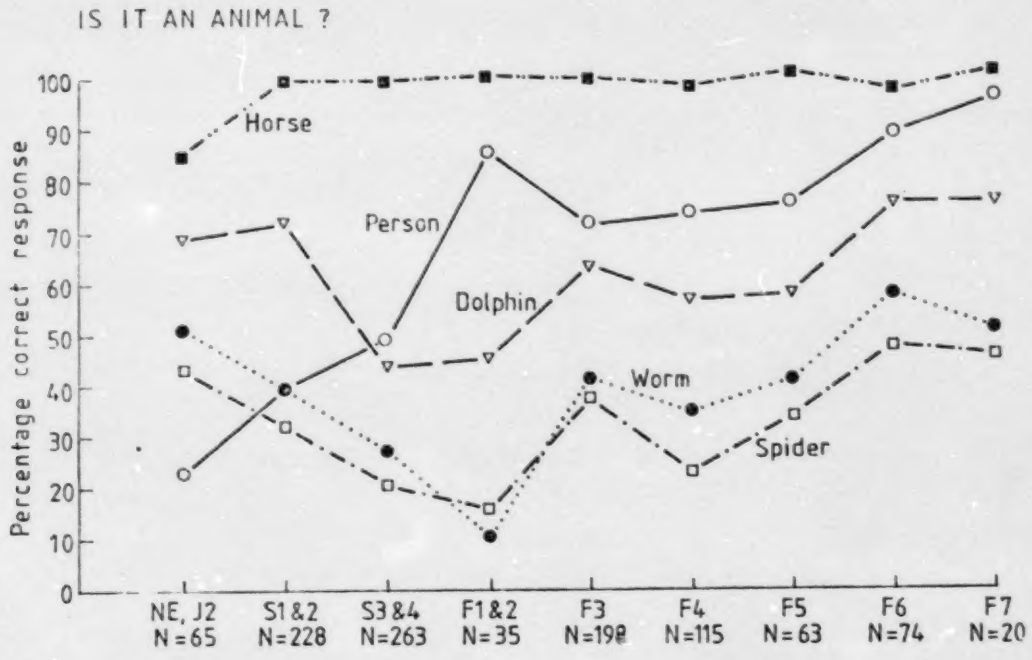

Figure 1. The Results of a Survey on Children's Meanings of the word 'animal'

While most considered the horse to be an animal, 50% or less, even at senior biology level, did not consider a worm or a spider to be an animal.

Other survey results for children's meanings to the words 'living' and 'plant' also illustrate that many students, even at Form 6 and 7 level do not have a scientific meaning for these words.

One possible explanation may be that teachers have assumed students have scientific meanings for these commonly used words and have not focussed their teaching on them. The Learning in Science Project team has developed a set of teaching activities to focus on the teaching and learning of the scientific meanings of these three basic ideas. This booklet provides the background information for the accompanying booklet on suggested teaching activities. It gives information as to scientists' meanings of the words 'living', 'animal' and 'plant' and children's meanings of these words.

THE SCIENTIST'S MEANING OF 'ANIMAL' AND 'PLANT'

NB. THIS IS INFORMATION FOR TEACHERS ONLY. IT IS NOT APPROPRIATE LESSON MATERIAL FOR STUDENTS OF FORM 5 OR UNDER.

The main difference between animals and plants is the way in which they feed. Animals require food in the form of substances which contain particular organic[1] molecules (protein, fats and carbohydrates). These molecules are altered chemically by the animal during digestion to provide materials for growth and energy release. This is known as consumer (or heterotrophic) feeding.

Plants use inorganic substances (minerals, water, and carbon dioxide) and solar energy in photosynthesis to make organic substances for growth and energy release. This is producer (or autotrophic) feeding.

In simple terms, animals must eat other living things, or their remains, for food and therefore a source of energy, while plants can make their own food during photosynthesis, and use this food for their source of energy.

However, some living things cannot be classified as animal or plant on the basis on how they feed. For example, Englena, a tiny one-celled organism (or

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1 Organic molecules are those that contain carbon, hydrogen and oxygen atoms. These molecules are found in living things and their remains.

living thing) eats other living things like an animal but is also able to make food through photosynthesis. Other organisms, for example, bacteria, fungi, do not neatly classify as plant or animal. Biologists themselves differ in their classification of these 'in-between' organisms. We will follow those biologists who divide living things into five groups - the plants, the animals, the Monera, the Protista, and the Fungi. The 3 smaller groups or kingdoms are:

(a) The Monera. The members of this group are the bacteria and the blue-green algae. Both these kinds of organisms lack an organised nucleus, are microscopic and one-celled. The type of feeding in this group is diverse. The blue-green algae are producers (autotrophs) as are some bacteria. Most bacteria are animal-like in that they are consumers. Other bacteria are chemosynthetic as they get their energy from chemicals.

(b) Protista. Into this kingdom are grouped the algae (including slimemoulds and seaweeds) which are producers, and the single celled organisms such as Amoeba and Paramoecium, which are consumers.

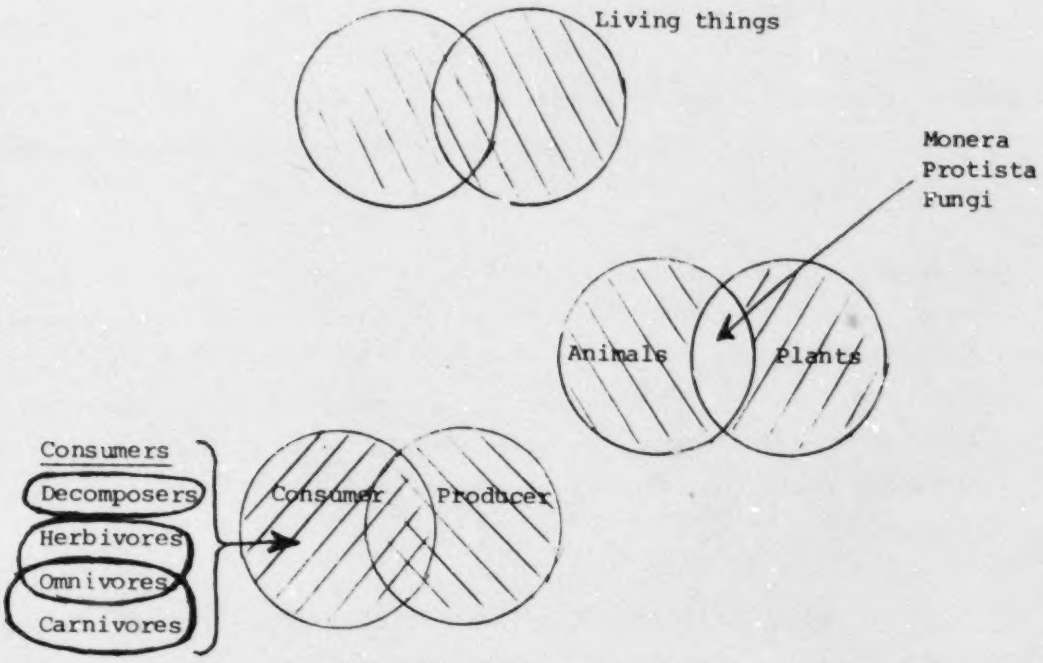
(c) Fungi. The fungi, for example, bread mould, mushrooms and toadstools are grouped together in this kingdom. Fungi are consumers.

The two other kingdoms are:

4. Plants, which include the mosses, ferns, conifers or pine trees e.g. totara, kauri, and the flowering plants e.g. grasses, fruit trees, vegetables. All are producers. A few plants, e.g. the Venus fly trap and sundew also feed in an animal-like way but this is not their main mode of feeding. The Venus-fly trap for example, is a green plant and obtains most of its food through photosynthesis.

5. Animals. All animals are consumers. They must feed on other animals and plants or their remains. Examples of animals are sponges, jellyfish, sea anemones, worms, snails, crayfish, flies and other insects, spiders, seastars, fish, frogs, snakes, birds, and mammals.

The relationship between these groups can be illustrated.



The main difference between animals and plants is the way they feed. This difference gives rise to two other differences. Plants do not need to move in order to obtain food, since the water and carbon dioxide for photosynthesis are readily obtainable. Most animals move to obtain their food although some animals do not, e.g. sponges, oysters, barnacles as water currents bring fresh food supplies to them.

Plants have neither sense organs nor a nervous system. They also respond slowly through growth to light, gravity and water, for example. Animals have some or all of the senses of sight, hearing, taste, touch, smell and a network of nerves to co-ordinate the senses and movement.

Another difference is in cell structure. For example, the animal cell lacks the rigid, cellulose cell wall of the plant cell.

Consumers can be further sub-divided into herbivores (the plant eaters); carnivores (the eaters of animals) and ominivores (the eaters of plants and animals). The term 'decomposer' is given to micro-organisms, such as bacteria and fungi which are also consumers, but which feed on dead animals and/or plants or on their waste products.

A meaning of Animal and Plant for Pupils Up to Form 5

When teaching about animals and plants to pupils in Form 5 or below it is adequate to say:

1. Living things are the animals and plants.
2. Animals are the consumers, plants are the producers.
3. Most animals move (but not sponges, oysters, mussels, barnacles, for example). Plants do not move of their own accord.
4. Animals have some or all of the senses of smell, taste, sight, touch, hearing and nerves. Plants do not.

Difficulties. Most pupils know of bacteria and fungi. At this level of teaching it is adequate to say that the bacteria and fungi may appear to be like plants but they feed like animals, the consumers. It is not necessary to concentrate on this at this level.

CHILDREN'S MEANINGS OF 'ANIMAL' AND 'PLANT'

We, as science teachers are interested in two aspects of the meanings children have for the words 'animal' and 'plant'. Firstly, what do children consider to be examples of animals and plants? Secondly, what reasons or characteristics do children use to categorise something as animal or plant or neither?

The following is a summary of interviews with New Zealand school pupils (see Appendix A) as to their meanings of the words 'animal' and 'plant'.

Children's meanings of 'Animal'

Many children see animals as only the larger land mammals, such as those found on a farm, in a zoo or jungle, or in the home as pets. Their range of examples of animals is narrower or more restricted than that of a biologist.

The reasons used by many children to categorise something as an animal differ from those used by a biologist. For example,

(i) Number of legs

"Yes (a cat is an animal) it's got 4 legs."
(6 x Std 4; 3 x F1; 2 x F3; 3 x F5)[2]

"No (a spider is not an animal) because animals don't have 8 legs".
(1 x Std 4; 2 x F1)

"No (a bird is not an animal) because it's only got 2 legs."
(1 x F1; 1 x F3)

"No, (a worm is not an animal) it's got no legs"
(3 x Std4; 1 x F1; 2 x F3; 3 x F5)

(ii) Size Animals are a large size to many children.

"Yes (a cow is an animal), it's big."
(1 x Std 4; 1 x F3; 1 x F5)

Small creatures are not considered animals by many children.

"No (a worm is not an animal) it's an insect, most insects are small."
(1 x Std 4; 1 x F5)

"An insect is something quite small ...."
(2 x Std 4; 6 x F3; 1 x F5)

Whilst all insects are small, a scientist would consider all insects to be animals. A worm is not an insect as it does not have 3 parts to its body (head, thorax, and abdomen), and does not have 6 legs. A worm, is however, an animal as it eats decaying plant material in the soil, (it is a consumer), it moves, and has a nervous system.

(iii) Habitat

Many children consider animals to be the creatures that live on land.

"Yes (the elephant is an animal) it's on land"
(1 x F1; 1 x F3; 1 x F5)

"No (a fish is not an animal) it lives under the water."
(2 x Std 4; 2 x F1)

"Yes (an elephant is an animal) it lives in the jungle."
(1 x Std 4; 3 x F1)

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2 These refer to the students who gave this kind of answer. For example 2 x F3 means two Form 3 students gave an answer similar to the quotation given.

(iv) Fur

For some children animals are the creatures with fur.

"Yes (a cat is an animal) it's got fur"
(3 x Std 4; 4 x F1; 2 x F5)

"No (a worm is not an animal), it's got .... no fur."
(1 x F1)

Noise Production Some children consider animals those creatures that make a noise.

"Yes (a cat is an animal) ... makes sounds."
(1 x F5)

"Yes (a boy is an animal) ... talks."
(2 x F5)

These characteristics of legs, terrestial, fur, size and noise production, whilst characteristics of some animals, are not characteristic of all. When these characteristics are used as reasons to categorise organisms as animals or not, they limit the range of examples of animals. Hence the children who used these reasons to decide if something is an animal or not, had a meaning of the word that is narrower than the scientific one.

Other reasons used by children are similar to those used by scientists to decide something is an animal or not.

(i) Movement

"Yes (the frog is an animal) because it moves"
(1 x Std 4; 4 x F1; 4 x F3)

"No (grass is not an animal) it grows in the ground and doesn't move around like an animal does."
(3 x Std 4; 3 x F1; 2 x F3; 1 x F5)

(ii) A well developed nervous system

"Yes (a fish is an animal) it's got a brain."
(1 x F1)

"Yes (a person is an animal) he's got the five senses."
(1 x F1)

(iii) Feeding

"Yes (the lion is an animal) it lives like other animals, and it goes around and eats other animals."
(2 x F3; 2 x F5)

Often pupils do not distinguish between animal (consumer) feeding and plant (producer) feeding. The green plants or producers make their own food through photosynthesis. Animals (most of the consumers) must eat other animals and plants to obtain their food. Many pupils also consider animals feeding as referring to only the carnivores (animal eaters).

In summary, many children have a restricted meaning of the word 'animal' compared to that of a biologist. Many children do not see birds, fish, insects and humans as subsets, but as comparable sets, to the set of animals.

But we as adults often use this restricted meaning when we use the word 'animal' in an everyday sense. A scientist considers people as animals as they are consumers, move, have a nervous system, sense organs and have cells without cell walls. However, many food shops display the sign:

"No animals allowed."

If we interpret the sign from a scientific viewpoint we cannot go in. To understand the intended message, we need to interpret the word 'animal' in the everyday or restricted sense, that is, meaning only cats, dogs, horses etc.

We as science teachers, need to clarify to students that there are two meanings for the word 'animal'. One (the narrower meaning) is appropriate to use in an everyday situation, and one (the wider meaning) is appropriate to use in the scientific situation (say in the science lesson).

Children's meanings of 'Plant'

Many children have a narrower meaning of the word 'plant' compared to a scientist. Many do not consider the vegetables; the weeds; and hard, large trees to be plants.

Few children use the abstract reasons of producer feeding and cell structure to categorise something as a plant. The reasons used by children, while not characteristic of all plants, do pertain more to plants than to animals. For example

a. It grows in the ground

"Yes (grass is a plant) it grows in the ground."
(2 x Std 4; 3 x F1; 4 x F3; 2 x F5)

b. Leaves

"Yes (a dandelion is a plant) it's got leaves."
(5 x Std 4; 3 x F1; 2 x F3; 1 x F5)

c. Flowers

"Yes (a poppy is a plant) it's got flowers."
(6 x Std 4; 3 x F1; 5 x F3; 3 x F5)

d. Stem

"Yes (a thistle is a plant) .... the stem."
(1 x Std 4; 2 x F3; 1 x F5)

e. Colour

"Yes (a fern is a plant) it's green."
(1 x Std 4; 3 x F3; 1 x F5)

f. Roots

"Yes (a tree is a plant) it has roots like other plants."
(1 x F1; 3 x F3; 1 x F5)

g. Requirements

"They (plants) need sunlight, they need water."
(1 x Std 4; 1 x F3)

h. Immobility

"Yes (seaweed is a plant) .. it doesn't run around."
(1 x F1; 1 x F3; 1 x F5)

However some children use reasons that are unacceptable to a scientist:

(i) Size Some children considered plants to be small in size.

"No (a tree is not a plant) it was a plant when it was little but when it grows up, it wasn't, when it became a tree it wasn't." (1 x Std 4; 1 x F3; 1 x F5)

(ii) Hardness Only the soft plants are called plants by some children.

"Well, the trunk (of the pinetree) isn't a plant but the leaf parts are like a plant. They do the same thing as a plant. (Why would you say the trunk part wasn't a plant?) Because its hard." (1 x F5)

(iii) Plants are those which are cultivated

"Yes (a poppy is a plant) it doesn't grow wild, you need to grow it." (1 x F3)

"No (grass is not a plant) it's a weed, it grows naturally." (1 x F3)

(iv) The vegetables are not plants

Some children do not see vegetables as plants.

"No, (the carrot is not a plant), it's a vegetable, when we chop something up for a stew, we eat it." (2 x Std 4; 3 x F3; 3 x F5)

In summary, as with the word 'animal' many children have a narrower meaning of the word 'plant' compared to that of a scientist. This narrower meaning results from using a different set of reasons to distinguish plants from other things. Many children do not consider weeds, trees and vegetables to be subsets of plants but to be comparable sets to the set of plants.

We as science teachers, need to clarify to students that there are two meanings for the word 'plant'. One (the narrower meaning) is appropriate to use in an everyday situation, and one (the wider meaning) is appropriate to use in a science lesson.

THE SCIENTIST'S MEANING OF 'LIVING'

NOTE: THIS IS INFORMATION FOR TEACHERS ONLY. IT IS NOT APPROPRIATE LESSON MATERIAL FOR STUDENTS OF FORM 5 OR UNDER.

It is not easy to define the scientist's meaning of life and living Definitions of living things include the ideas of:

a. cells, containing the nucleic acids DNA and RNA. The possession of nucleic acids implies the ability to grow and reproduce.

b. homeostasis. This is the maintenance of a stable, unchanging internal environment in a changing external environment. For example, living things are able to maintain a steady internal composition of minerals and water in their cells, despite fluctuations in the amounts of minerals and water around them. The ability to carry out homeostasis, implies the ability to detect changes in the environment, to be sensitive to stimuli.

c. metabolism. This is a collective term designating the many chemical and physical reactions carried out by living things, and the resulting energy changes. Included in these reactions are cellular respiration[3], digestion[4], photosynthesis.

d. complexity and organisation. Even the simplest living things are highly organised, complex and self-directing.

Life may be defined as:

"A living form is essentially a highly organised, self-directing complex system of chemically and physically defined structures capable of utilising the matter and energy of its environment (by means of integrated and self

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3. Cellular respiration refers to a complex set of chemical reactions which occur in a living cell to release energy from food for the cell's various life processes.

4. Digestion is a physical and chemical breaking up of complex food molecules into molecules small enough in size to be taken up by a cell.

determined chains of physical and chemical reactions) for growth and reproduction."[5]

This is in contrast to an older definition which focussed on the characteristics of living things of movement, respiration (often referred to incorrectly and loosely as breathing), sensitivity, growth, reproduction, excretion and nutrition), and summarised in the mnemonic M.R.S.G.R.E.N.

A meaning of living for Pupils up to Form 5

As mentioned previously, the scientist's abstract concept of 'living' is not appropriate content for lessons for primary, intermediate, or junior secondary pupils. We are more interested, at this level, in whether pupils can categorise things as living or non-living as would a scientist.

A modified and simpler meaning for younger pupils is that living things grow, reproduce (have young/babies), feed, and are made of cells (or flesh).

Therefore a cat is living as it grows in size, can reproduce its own kind (have kittens), and feeds. A car is not living as it does not grow and does not reproduce its own kind.

However the best meaning of the word at this age level is that living things are the animals and plants.

Children's meanings of the word 'living'

We, as science teachers, are interested in two aspects of the meanings children have for the word 'living'. Firstly, what do children consider to be examples of living things? Secondly, what reasons or characteristics do children use to categorise something as living or not-living?

The following is a summary of interviews with New Zealand school pupils (see Appendix A) as to their meaning of the word 'living'.

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5. Nason (1968) Essentials of Modern Biology Lesley & Sons, New York.

Many students have a wider meaning of the word 'living' than that used by a scientist. They have more examples of living things than would a scientist. Some pupils consider a fire, cloud, river, car, bike and the sun to be living whereas a scientist would not.

Some of the reasons used by the pupils to classify something as living or non-living are acceptable to scientists. For example,

"Yes, (a spider is living), it can move."
(1 x Std 4, 3 x F1, 2 x F3; 5 x F5)

"No, (a bicycle is not living) it doesn't breathe."
(3 x F3)

"Yes, (a bird is living) it eats and drinks."
(1 x F1; 1 x F5)

"Yes, (a tree is living) because it grows taller."
(1 x Std 4; 3 x F1; 4 x F4; 6 x F5)

"No, (the sun is not living) it can't smell and it can't see."
(1 x Std 4)

"Yes, (a butterfly is living) ... it mates."
(1 x F1, 1 x F3)

"Yes, (grass is living) it's got cells."
(1 x F5)

But as mentioned before, these reasons are often used to classify as living, things that a scientist would consider non-living:

"Yes (a cloud is living) it moves in the sky."
(1 x Std 4, 1 x F3)

"I sort of think the river is alive because it's always moving, all the time and never dies out."
(2 x Std 4, 2 x F3, 1 x F5)

"Cloud, it moves, it starts off little and gets bigger and old. We say it was a living thing."
(1 x Std 4; 1 x F3)

"Yes (a fire is living) you need to keep on feeding the fire to make it go."
(1 x Std 4)

"Yes (a fire is living) it needs oxygen to breathe."
(3 x F3; 1 x F5)

"Yes (the cloud is living) it creates its own self."
(1 x F3)

Some pupils consider the object to be living at some times but not at others. For example, a vacuum cleaner is considered by some to be living if it was switched on:

> "I'm not sure because it's sort of living and it isn't living ... it's sort of living when it's switched on ..." (1 x F1; 2 x F3)

Some pupils use reasons that would <u>not</u> be acceptable to a scientist. For example:

i. <u>a form of energy, such as heat or light.</u>

> "Yes, (the sun is living) it gives off heat, light and everything." (1 x F3; 2 x F5)

ii. <u>Makes a noise</u>

> "Well, when it (a vacuum cleaner) makes a noise, it's sort of living." (1 x Std 4; 2 x F5)

> "Because he (a boy) can talk" (3 x Std 4; 1 x F1; 1 x F3)

iii. <u>Usefulness</u>

> "Yes (a car is living) it can take us around ... the world, and it can take us to work." (1 x Std 4)

> "Yes (a river is living) it gives us water." (1 x Std 4)

iv. <u>Survivorship or durability.</u>

> "It (the book) can stay for a long time." (1 x Std 4)

> "A candle lives for so long ... when you light it. Your wax starts melting and then just keeps on going." (1 x Std 4)

v. <u>Ability to think, has a mind-of-its-own</u>

> "Yes (a butterfly is living) because it controls itself, doesn't have to have anyone to control it." (1 x F3)

> "Yes (a fish is living) it's got its own thinking." (1 x F5)

vi. Body organs.

> "Yes (a butterfly is living) it's got different parts of the body, got a heart and a brain."
> (1 x F3; 1 x F5)

These last two reasons (ability to think, and body organs) whilst not incorrect for some living things, would not be used by a scientist to distinguish between living and non-living things.

In summary, many pupils of all ages (standard 4 to Form 5) use the word 'living' in a wider sense than would a scientist. They consider a wider range of things to be living, than would a scientist.

However, we as adults, also use this wider meaning of the word 'living' when we use this word in a metaphoric sense. For example, we talk of the 'living bible' or of the 'living flame' in advertisements for natural gas. We use the word as if the bible or flame was living. We may not consider the book or flame to be living from a scientific viewpoint but we may consider it living in a metaphoric sense, as if it was living.

If we are to understand the message in such phrases as the 'living bible', the 'living flame' we must interpret the word 'living' in the metaphoric not scientific sense. We, as science teachers, may need to clarify to the students, which is the appropriate meaning to use in different situations.

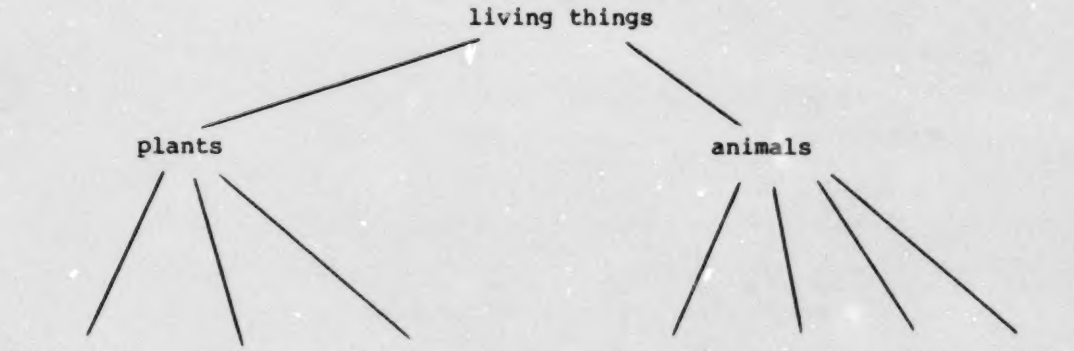
Difficulties

Many children consider the fire to be living. They see it as carrying out the processes of feeding (on fuel); breathing (it uses oxygen); reproduction (sparks start new fires); growth (it gets bigger as it spreads); it moves by itself (the flames flicker) and it gives off wastes (the smoke). It may help to continue the discussion to include the fact that fires are not made of cells (flesh) are not highly organised inside, and to explain what fire is. Fire is the energy release during burning or combustion. During burning the fuel and oxygen react to form new substances (carbon dioxide, water vapour, and sometimes smoke). The flame is the heat and light energy, that was once stored in the fuel but which is now being released. Also if living things are defined as the animals and plants, then the fire is not living as it is neither an animal or a plant.

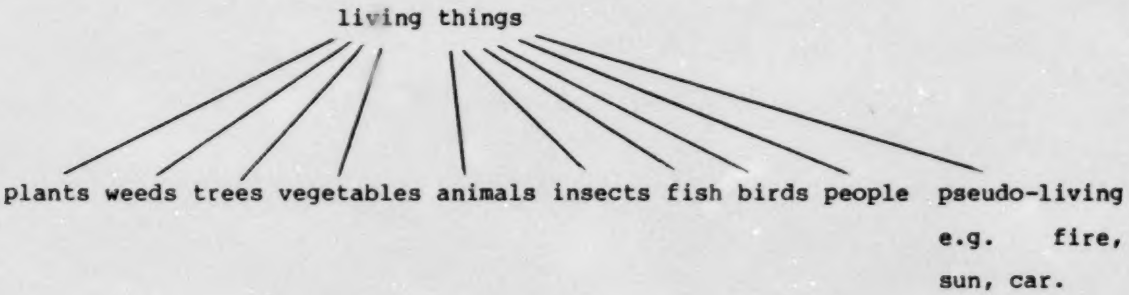
SUMMARY

The meanings children give to the words 'living', 'animal' and 'plant' indicate that their hierarchical categorisation may not be the same as that of a scientist.

For example, a scientist's categorisation may be simply represented as:



For many students, the categorisation may be represented:



The biological subjects of trees, vegetables, weeds and of people, insects, fish and birds are seen as comparable sets to the sets of plant and animal, not as subsets.

Children do have meanings for the words 'living', 'animal' and 'plant'. But these meanings are often different to the scientific meaning. Children often have a wider meaning of the word 'living' and narrower meanings of the words 'animal' and 'plant' compared to that of a scientist. These meanings used by children correspond to the metaphoric use of the word 'living' and to everyday use of the words 'animal' and 'plant'.

Recent findings (see Appendix 2) suggest that present teaching, which does not focus on clarifying the scientific meanings of these words, may promote the acceptance and sole use of the alternative meanings of these words in science classrooms.

We cannot assume that students use scientifically acceptable meanings for the words 'living' 'animal' and 'plant' in our classrooms. We need to focus our teaching on clarifying and describing the scientific meanings of these basic and commonly used words.

Appendix 1

These interviews were carried out as part of the in-depth phase of the Learning In Science Project, at Waikato University in 1980.[6]

The method of obtaining data was an 'interview-about-instances' procedure developed by Osborne and Gilbert (1979).[7]

There were three different sets of interviews. One to ascertain 32 pupils' concepts or meaning of 'living'; one to explore a further 39 pupils' concepts of 'animal'; and one to explore another 29 pupils' concepts of 'plants'. Each pupil in the total sample of 100 was interviewed about one concept only.

The pupils were selected from 4 different schools, across approximately twelve different classes. The teachers were asked to select children of average ability for the investigation. However, this was not always possible and seven pupils of above-average ability, were also interviewed. There were 49 boys and 51 girls in the sample, including both European and Polynesian pupils.

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6. A full account of this research can be found in Stead (now Bell) B.F. (1980) The Description and Modification of Some Students' Biological Concepts, unpublished M.Ed. thesis, University of Waikato.

7. Osborne R.J. and Gilbert J.K. (1979). Investigating Student understanding of Basic Concepts Using an interview-about-instances approach, Research in Science Education, vol 9, pp 85-93.

In an interview situation, the pupils were shown diagrams on cards (only one per card). In the interview on 'living' the illustrations on the cards shown, in the sequence of presentation, were: book, boy, seagull, fire, snail, bicycle, worm, car, sun, mushroom, vacuum cleaner, rock cod, grass, butterfly, cloud, tree, river, candle, and spider. Illustrations of living things (both animal and plant) and non-living were represented on the cards.

In the interview on 'animal' the illustrations on the cards shown, in the order of presentation, were; seagull, cow, spider, worm, grass, cat, mushroom, rock cod, boy, frog, snail, elephant, snake, fire, lion, whale, car, tree and butterfly. Again, instances of animals, plants and non-living instances were presented.

In the interview on 'plants', the illustrations on the cards shown, in the order of presentation, were: grass, elephant, seaweed, poppy, thistle, seeds, tree, mushroom, fern, dandelion, carrot, gorse, snail, pine tree, and cabbage. Again, instances of the concept (plants) and non-instances (animals) were represented on the cards.

The interviews were structured in the sense that the sequence of cards in each of the three different groups of interviews was the same, and the same two questions were asked with each card in an interview. The two questions asked were:

in the 'living' interviews	1.	"Is the _____ living?"
	2.	"What tells you that?"
in the 'animal' interviews	1.	"Is the _____ an animal?"
	2.	"What tells you that?"
in the 'plant' interviews	1.	"Is the _____ a plant?"
	2.	"What tells you that?"

The first question in each case investigated if the pupils categorised the instance as an example of the concept or not. The second investigated the reasoning used to make the categorisation. However, further questions were asked when appropriate, in order to gain a clearer understanding of each pupil's concept under investigation. The beginning of each interview, after introductions, was as follows:

"I'm interested in science lessons and, in particular, the different meanings people have for different words. For example, the teacher may use a word in a class, you'll mean one thing by it and the person sitting next to you may mean something else, something slightly different. I would like to learn from you what you mean by the word 'living' (or animal or plant)".

The first question with the first card (and with later cards if need be) was "In your meaning of the word 'living' (or animal, or plant), is a _____ living (or an animal, or a plant)?" At the end of an interview the pupil was asked to give her/his meaning of the word, either 'living', 'animal', or 'plant', in a sentence or two.

The pupils were individually interviewed in a small room or office. The interviews were taped with the consent of the pupil, and later transcribed to obtain a written record of the interview for the later collation of results.